Biomechanical Characterization of Soft and Hard Tissues for Finite Element Modeling of Hands

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INTRODUCTION

- Finite Element (FE) modeling of the hand to date has focused on individual components and no, or very limited, information on tissue material properties is available to make the models more realistic yet.
- Whole hand modeling has potential use in simulating/assessing reconstructive or salvage procedures prior to in vivo or cadaver use.
- Purpose: Determine biomechanical properties of major supporting structures of the hand.

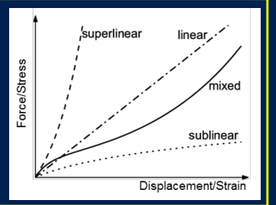
FE Model Components

1) Geometry

- Obtained from CT/MRI Images for soft and hard tissue geometrical definition
- Assembly and integration into CAE/FE software

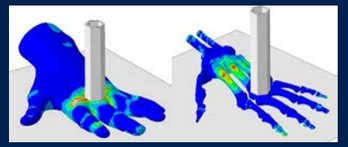
2) Material Properties

- Force-Displacement curves
- Stress-Strain diagrams
- Coefficients for constitutive models
- Obtained from biomechanical tests



3) FE Model Applications

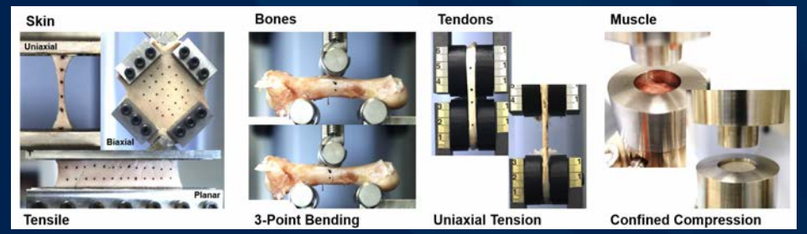
- Stress/Strain analysis
- Damage prediction
- Protective/implant devices



METHODS

- Four matched pairs of fresh frozen cadaver hand dissected for biomechanical testing.
- Specimens mounted on electromechanical test frame and loaded to failure at rate of 25mm/min.
- We investigated the biomechanical behavior of dorsal and palmar skin, metacarpal and phalangeal bones, flexor and extensor tendons, and thenar and hypothenar muscles and the following testing methods for each type of tissue:

Specimen	Testing Method
Dorsal and Palmar Skin	Uniaxial, Planar, & Biaxial Tension
Tendon	Uniaxial Tension
Bone	Three-Point Bending
Muscle	Confined Compression



RESULTS

- Mean specimen age 64 (SD8.9)
- Δ Volume Ratio of Muscle at 1000N = 0.95

Specimen	Method	Mean Force (SD)
Dorsal Skin	Uniaxial	27.4 N (SD 21)
	Planar	681 N (SD 459)
	Biaxial	565 N (SD 401)
Palmar Skin	Uniaxial	27.1 N (SD 11.4)
	Planar	574 N (SD 172)
	Biaxial	520 N (SD 188)
Metacarpal	Three-Point Bending	1005 N (SD 276)
Prox. Phalanx	Three-Point Bending	871 N (SD 502)
EDC	Tension	523 N (SD 113)
FDP	Tension	692 N (SD 154)
FDS	Tension	636 N (SD 176)

CONCLUSION

- Biomechanical evaluation of soft and hard tissues of the hand provided valuable strength and deformation information for FE modeling
- FE models of the hand have a broad application both in surgical planning, education, and injury prevention.

e-Poster presented at the American Association for Hand Surgery AAHS 2022 Annual Meeting, January 11-15, 2022, Carlsbad, California, USA.